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DR. JAMES G. CARR, Chicago, *Editor*

DR. GILBERT H. MARQUARDT, Chicago, *Associate Editor*

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ROENTGENOLOGICAL MEASUREMENTS OF THE THORACIC AORTA

It is known that aortic valvular disease may exist and be apparent clinically without roentgenological evidence of dilation of the aorta. It is also known that the aorta may be definitely dilated without clinical evidence of its existence. The absence of roentgenological signs of aortic dilatation is of value in both differential diagnosis and prognosis. Evidence of slight aortic dilatation is of little significance unless associated with the more important clinical findings, but roentgenological evidence of aneurysm is of extreme importance.

Roentgenoscopy is used particularly with the aid of the orthodiagraph in estimations of the size and shape of the heart but these methods are not applicable to measurements of the aorta. When estimations of size are attempted, too much depends upon an impression gained only from long experience. A large aneurysm is easy to visualize but it is very difficult to determine moderate or slight changes in the aorta. Experienced observers are often misled by such impressions particularly when they are aware that the patient has a diastolic murmur or a positive Wasserman. It appears that during roentgenoscopy the aorta is more clearly visualized than when the same shadows are seen on the roentgenograph. This is due in part to the fact that the shadow seen can be identified by the character of its motion. Observation of the aortic shadow in various views is of distinct advantage because small local areas of dilatation may thus be seen in profile. A sudden forceful enlargement of the aortic root shadow with systole, followed by rapid reduction in the shadow (Corrigan pulse) is excellent additional evidence that dilatation of the aorta, if present, is due to valvular disease rather than to a normal variation, hypertension or arteriosclerosis. The impressive pulsations of the aorta, seen in the laborer or athlete, may be mistaken for abnormal changes. The mediastinal shadow is markedly influenced by the position of the diaphragm, and impressive shadows are also noted in the normal when the aorta is tortuous or the spine is deformed.

While the magnification obtained during roentgenoscopy aids in visualization of small changes it also leads to an incorrect estimation of size. This magnification is influenced by: the distance of the roentgenoscopic screen from the patient; the distance of the tube from the patient and the size and position of the patient. These factors of magnification and distortion are better understood when one compares roentgenoscopy with a tube distance of twenty-five inches with that of a tube distance of seven feet, and similar, more lasting impressions are gained by comparing short distance roentgenoscopy with roentgenograms taken at seven feet. Early in one's experience in roentgenoscopic examinations of the heart and aorta many normal patients are suspected of having abnormal mediastinal shadows and the more often it is possible to check impressions gained by this examination with the teleroentgenogram the less frequently is dependence placed on roentgenoscopy.

The patient suspected of cardiovascular disease should be examined both roentgenoscopically and roentgenographically, the roentgenogram being taken at six or seven feet in the standard postero-anterior and both oblique positions, with barium in the oesophagus. An attempt should then be made to apply all accepted measurements to confirm or deny impressions gained by other examinations.

The distal portion of the arch of the aorta can be measured by roentgenological methods. This measurement is based upon anatomical facts and there is general agreement as to the method and its accuracy. This portion of the arch of the aorta is in contact with the oesophagus, trachea and left lung. When the oesophagus is filled with barium and the patient is so placed that a minimum measurement is obtained between the left margin of the aortic knob and the oesophagus, the actual diameter of the aorta may be determined by deducting the thickness of the oesophageal wall (2 mm.). The correct position of the patient for this measurement is either the postero-anterior or the right anterior-oblique view. This can be readily determined by roentgenoscopic observation. The measurement thus obtained, of the arch of the aorta, in the middle-aged adult averages 3.5 cm. If extreme measurements of the young and old adults are included a normal variation of from 2 to 4 cm. is encountered. There is a definite relation of the size of the aorta to the size and stature of the patient, that is, a small female should have a small aorta whereas a male weighing two hundred pounds may show an aorta 4 cm. in diameter.

The measurement of the arch of the aorta obtained from the teleroentgenogram by the above method cannot be compared with measurements done at post-mortem examinations, because post-mortem measurements are markedly influenced by elastic tissue contractions, absence of the positive pressure of the blood and the negative pressure of the lungs, the effect of formalin fixation and other changes. In a series of fifty-six post-mortem measurements done shortly after death on individuals of from forty to ninety years of age, the average diameter of the arch of the aorta was found to be 1.8 cm. There was a normal variation of from 1.6 cm. to 2.2 cm., the maximum figure being obtained on a male ninety years of age. When these normal measurements are compared with those taken from the teleroentgenogram it is noted that they are approximately one-half as great as the normal values obtained roentgenographically.

Further evidence that post-mortem measurements of the normal aorta are of no value in checking roentgenological findings is illustrated by comparing

the average normal post-mortem measurement with two direct measurements of the arch of the aorta done by a surgeon during operations upon the left lung. These measurements were done on patients having carcinoma of the left lung and without any evidence of cardiovascular disease. One patient was thirty-five years of age; the arch of the aorta was easily measured during the operation and metal clips were placed at the site of the measurement, one at the superior and one at the inferior margin of the aortic arch. The measurement at operation was 3.5 cm. and this checked exactly with further measurements taken from a teleroentgenogram. The measurement in the second patient amounted to 3.8 cm. and in this patient the arch of the aorta could be visualized on the lateral view of the chest taken at seven feet. This measurement also checked exactly with the X-ray measurement. No post-mortem was obtained on either patient but the second patient is living and well, without change in the heart or aorta, five years later. From these two measurements of 3.5 and 3.8 centimeters, representing an undoubted measurement of the normal aorta, it is noted that they are twice as large as the normal noted at post-mortem.

After consideration of the anatomy of the beginning of the ascending aorta it is obvious that this portion of the aorta cannot be measured by roentgenologic methods, because no two of its walls are consistently in contact with the lung or any other structure sufficiently different in density. While it is true that the anatomical relationships of the ascending aorta as they exist in the living are not comparable to those seen at post-mortem, it is extremely doubtful that there is sufficient difference to allow visualization. Certain portions of the ascending aorta and the beginning of the arch before the great vessels are given off are sometimes visualized, particularly in the left anterior-oblique view. The degree of visibility is dependent entirely upon the presence of calcification, or the degree to which the aorta protrudes into or is surrounded by the adjacent lung. Calcification, elongation, tortuosity or dilatalion of the aorta often produce changes permitting fair visibility and in such cases a direct measurement should be done.

Due to the invisibility of the ascending aorta except under certain conditions various attempts at measurements of the diameter have shown a range of normal measurements from 1.8 to 5½ cm. Confusion has been added by the inclusion of younger age groups which are even more difficult to measure, and if measurements were possible they would probably be of no clinical value. Some authors have suggested a normal measurement of the ascending aorta of between 1.8 and 3 cm. when it is known that an undisputed measurement of the arch of the aorta distal to the great vessels of the neck and subclavian arteries, in the same group of subjects, yields a normal value of 2 to 2.4 cm. This tendency to suggest a small normal measurement for both the ascending and transverse portions of the aorta is based upon the post-mortem measurements and these obviously cannot be applied to the living patient. Certainly there is no logic in suggesting a measurement of the ascending aorta which is smaller than the arch after the large vessels to the neck and arms have been given off. A measurement of the ascending aorta which is less than the arch should not be accepted unless the arch is pathological.

Various visible structures which are in contact with the posterior aspect of the ascending aorta have been used as landmarks for measurement in the right oblique view. The trachea and left main bronchus appear to outline the posterior aspect of the aorta and measurements taken from the trachea to the anterior margin of what appears to be the ascending aorta vary from 1.8 to 3 cm. The small measurement obtained is probably due to the fact that the trachea is superimposed upon the posterior portion of the aorta and this gives a false impression. It is said that the anterior margin of the shadow of the aortic root may be obscured by the superior vena cava in this view.

In the left oblique position the right main bronchus is seen to pass downward in a direction parallel to the anterior convex margin of the ascending aorta. Anatomically this would appear to offer an accurate measurement but the right main bronchus is often difficult to visualize and since neither the aorta nor the bronchus are in the vertical axis of the body, the measurement varies considerably when the degree of rotation is altered. The normal measurement by this method is said to vary between 1.9 and 2.9 centimeters. Measurements have also been attempted in the left oblique view, using the shadow of the pulmonary conus as the posterior point of the measurement. The pulmonary artery lies in contact with the left posterior margin of the root of the aorta. If the patient is rotated to an angle of about forty degrees it is said that if the shadow of the pulmonary conus is bisected the point obtained represents the posterior margin of the aorta. Then if a measurement is taken by a horizontal line connecting this point with the anterior visible margin of the aortic root a normal value of 4½ cm. is obtained for patients in middle life. When it is possible to identify the pulmonary conus, and if care is taken to rotate the patient to the proper angle, this method gives a measurement which is probably correct. The proportion of the normal measurement of the ascending aorta (4.5) to the normal arch (3.5) is approximately the same as the proportion which is noted at post-mortem and it seems logical to conclude that this measurement of the ascending aorta is more accurate than those suggesting smaller values. The criticism of the measurement is chiefly that the shadow of the pulmonary conus cannot be readily identified and the measurement may also be varied by changing the position of the patient. Furthermore this measurement is above the clinically important aortic valve area. Another method of measurement in the left oblique position has been suggested. The posterior point of measurement is determined by following the left posterior border of the heart shadow upward and forward as far as it can be traced. Then the inferior portion of the arch and the distal posterior portion of the ascending aorta are traced downward as nearly as possible to meet the point already established. By connecting these two points in an arc, roughly parallel to the visible anterior margin of the ascending aorta, and then by measuring a horizontal line at the point where the curve of the heart chamber meets the ascending aorta, a value of 5.5 centimeters is found in the age groups at and beyond middle life. Criticisms for this method are that the borders of the heart and aorta cannot be traced except under unusual conditions. Furthermore that the posterior point of measurement includes structures other than the aorta.

SUMMARY

Due to the wide, normal range in the size of the thoracic aorta, considerable experience is necessary in evaluating roentgenoscopic and roentgenographic findings. These findings cannot be accurately checked by post-mortem examination. The arch of the aorta, distal to the great vessels of the neck, can be accurately measured roentgenographically and for the age groups when luetic aortitis is most common an average normal diameter of 3.5 cm. should be accepted. The ascending aorta cannot be accurately measured except under unusual conditions but a method which gives an average diameter of 4.5 cm. for the clinically important age groups should be accepted.

Aubrey O. Hampton, M.D.
Boston, Massachusetts